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ANALYSIS OF SUPPLIER SELECTION CRITERIA USING FUZZY AHP IN TEXTILE INDUSTRY IN INDONESIA

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Abstract

The purposes of this study are to determine the order of criteria and sub-criteria in supplier selection process by measuring the weight of each criteria and sub-criteria to find out the best supplier in each TPT industry sector for the company which become the subject of this study. The technique of collecting data is through questionnaire distribution to 5 respondents who are the experts of the company. The collected data were analysed using Fuzzy AHP approach. The result of this research will assist in giving beneficial solutions in decision making, especially in selecting the best suppliers based on supplier selection criteria and sub-criteria to supports an excellent supply chain management.

Keywords: *Fuzzy analytic hierarchy process, operations management, supplier selection, supply chain.*

INTRODUCTION

Decision making is a necessary activity in life for everyone because in any activity, people must make a decision while considering every choice that they have and the future outcome of their decision, as a short-sighted decision may bring disasters in the near future of someone. Such crucial action is becoming even more important for someone in the top position as a leader of an organization, as a short-sighted decision without enough considerations may cause chain reaction of chaos for other people in the long run. Therefore, a leader has the most important job with a lot of responsibilities. The same rule applied to countries' government who is responsible for millions of people's life. Indonesia, the world's largest archipelagic country, is also the fourth most populated country in the world with 263,991,379 population by 2017, and this number keep growing every year (Worldometers, 2017). This increasing number of population become a major concern for the government as it caused some serious issues such as poverty and unemployment.

Despite these problems, there is a high opportunity for Indonesia's economic growth through ASEAN Economic Community (AEC), a community of South East Asia nations that effectively active by the end of 2015, consisting Indonesia, Brunei Darussalam, Cambodia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam, with the main objective to bring equality and prosperity for each of its members by lifting every obstacles and boundaries that restrict the movement of workforces, goods, and services. While AEC gives Indonesia the opportunity to improve economy, it is also a challenge to improve the quality of human resources management in order to compete with other countries.

The demand of labor force in the textile and textile product industry (TPT) is increasing along with the improvement of industry performance that engaged in the labor-intensive sector. Indonesia Ministry of Industry (2017) stated that the TPT industry contributes about 17% of total TPT industry labor force.

Table 1. *Contribution of Manufacturing*

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Industry to Indonesian GDP.

Year	Contribution
2009	26.35%
2010	24.79%
2011	24.32%
2012	23.97%
2013	21.03%
2014	21.07%
2015	20.97%
2016	20.51%

Source: Central Statistics Agency (2017).

As shown in Table 1, manufacturing industry contribution to Indonesia's GDP is declining every year. Despite the decreasing percentage, Central Statistics Agency (2017) shows that the biggest contributor to Indonesia's economic growth based on the sectors is still placed by the manufacturing sector with 0.92% of the total economic growth which is 5.02%. Moreover, according to Central Statistics Agency (2017), Indonesia's manufacturing industry is in the top 10 of the world, placed side by side with UK, above Mexico and Spain. TPT sector increased by 1.92% compared to the same period in the previous year which decreased by 0.13%. The numbers show a relatively positive performance in both domestic and export market, a promising manufacturing industry with a lot of potential to grow and expand in the future (Bisnis Indonesia, 2017). Therefore, based on the National Industrial Development Master Plan (RIPIN) in 2015-2035, the TPT sector development is prioritized for it to contribute significantly towards the national economic growth. The TPT industry production process can be classified in 3 main areas. The first area (upstream sector) is mostly the production of fibre products; the second area is spinning, knitting, weaving, dyeing, printing and finishing; and the third area (downstream sector is the form of garment factories and other textile products. Beside the challenge to compete with other textile producing countries in South East Asia (Cambodia, Myanmar, and Vietnam), Indonesia must face other deal with other issues at hand such as the increasing reliance on imported raw materials, lack of investment, and old machines condition especially the weaving and knitting machines.

A particular trading company in TPT industry chooses to form partnership with manufacturers rather than having their own mills. By collaborating with the upstream sector, especially those with spinning, knitting, weaving, dyeing, printing, and finishing activities in their mills, the company is able to purchase raw knitting colourless fabrics which can be customized with different colours and shapes based on the considerations of fashion trends and customers' demand. The target market of the company is the downstream sector who produce garments in large quantity.

The company's supply chain management starts with purchasing raw knitting colourless fabric from a supplier and doing the colour immersions with the help from another supplier. The process could be done in the same supplier company if the result is close to customers' demand. The manager is not only responsible for the number of fabrics, but also the quality and colour according to customers' order. This process need a lot of quality control and good communication skills with both the supplier and the customer. Another important thing is to have warehouses to keep the finished fabric stocks.

Because of the large amount of costs in starting a manufacturing company, this company suffer a capital limitation that prevents them from having their own mills, therefore, this supply chain management is applied to maintain the company in a safe position in textile industry.

While the research about supplier selection has been done by several previous studies, studies about supplier selection with Fuzzy AHP technique in small industry in Indonesia is very limited as far as author' knowledge. Therefore, this research give contribution especially for Indonesia's textile industry.

The purpose of this research will determine the order of criteria and sub-criteria in supplier selection process of the company. This research is expected to give beneficial solutions in decision making of obtaining the best supplier based on the supplier criteria. Therefore, supply chain management is expected to go smoothly and well planned to maintain a good company's position in customers' mind.

LITERATURE REVIEW

Overview of Mobile Banking Customers in Thailand

Operation management is the activities of organizing, operating, and repairing a system for it to work effectively and efficiently (Russell and Taylor, 2014). Supply chain is one of the system and the activities to manage it is called supply chain management which is made up of parties that directly or indirectly receive and meet customers' demand (Chopra & Meindl, 2007). These parties are not only producers and suppliers, but also include carriers, warehouses, and even customers themselves. Supply chain management is a crucial part of companies as a correct usage of supply chain management can give companies significant competitive advantages (Mentzer, Myers & Stank, 2007).

Supply chain management is said to be successful when the flow of information, products and funds is done accordingly (Chopra and Meindl, 2007). Therefore, a proper and precise decision in managing supply chain must be made. There are three phases of decision making with different frequencies and time frames. The first one is Supply Chain Strategy Design, where the company prepares the supply chain for the next few years according to their marketing plan. The second phase is Supply Chain Planning, which take time about quarter to one year to plan the configuration of the supply chain, what need to be changed or fixed. And the final phase is Supply Chain Operations, which have time phase as daily or weekly and during that time, the decisions regarding individual customers are made.

To make the operation management successful, several decisions considering the situation of the company is mandatory. One of the decision need to be made is regarding the company's capability to manufacture their product. The decision to do Outsourcing, an act of using services from external providers to perform some internal activities of the company (Chase, Jacobs & Aquilano, 2009), is the solution for this problem. The company can focus on activities that are better in representing their core competencies (Chase, Jacobs, Aquilano, 2009) as it can create value or competitive advantage while reducing costs that are not very necessary.

Another crucial decision in managing supply chain is Supplier Selection. Verma & Pateriya (2013) argues that supplier selection process is part of quality, production, and logistics management for some companies. To improve the effectiveness of the entire supply chain system, supplier selection is crucial as a variety of method to measure supplier performance. Supplier selection issues only about who to buy and how much to buy (Ozfirat, Tasoglu, Memis, 2014). Selection of supply sources is the most important function in the purchasing department as an effective supplier selection process has the opportunity to reduce cost and effective resource control.

Decision-making is defined as the process of taking action relating to problems or opportunities (Ivancevich, Konopaske, Matteson, 2013) which usually consists of three steps; perceiving there are needs and dissatisfaction within oneself, decision to fill the needs, and the last is the awareness and dedication to make that decision (Arsham, 2010). There are several decision-making methods, but in this study, author will discuss about Multi Criteria Decision Making (MCDM).

Problems arise in Multiple Criteria Decision Making (MCDM) if there are several conflicting factors in the selection of suppliers, so there needs to be a cross-criteria analysis by the purchasing manager (Verma, Pateriya, 2013). Analytical Hierarchy Process (AHP) is a technique that helps decision makers to evaluate alternative options. Some criteria are considered important depending on the purchase situation so there is always a need to measure and weigh them. The AHP is a theory and methodology for relative measurement, which define as the proportions between some quantities (Brunelli, 2015). It suits properly for the problems that need to choose the best alternatives. However, AHP's capabilities are limited in dealing with uncertainty in decision-making that take place in the real environment (Ozfirat, Tasoglu and Memis, 2014).

Fuzzy sets and fuzzy logic are useful as great mathematical tools for modeling: nature and humanity, uncertain systems in the industry,

and facilitators for common sense reasoning in decision making that require complete and precise information (Khan, Jayant & Kumar, 2015). The fuzzy logic theory is based on fuzzy sets which are a natural extension of the classical set theory. A sharp set (also called crisp set) is defined by a bivalent truth function which only accepts the values 0 and 1 meaning that an element fully belongs to a set or does not at all, whereas a fuzzy set is determined by a membership function (Werro, 2015). Fuzzy or fuzzy logic set theory is a collection of theories that provide solutions for inaccuracy and ambiguity (Ma, Zhang, Yan, Cheng, 2014). The fuzzy information has been discussed by Zadeh in 1965 that provides a temporary idea of the fuzzy set and fuzzy logic and its application in real life (Ma, Zhang, Yan, Cheng, 2014).

The extension of AHP is developed to become fuzzy AHP because conventional AHP fails to reflect the human thinking style (Ganguly & Guin, 2013). The fuzzy-AHP methodology has been used as a tool capable of analysing, capturing the uncertainty of human judgment, its simplicity and its ability to solve multi-criteria decision-making problems (Mastrocinque, Mondragon, Hogg, 2016). According to Khan, Jayant and Kumar (2015), fuzzy analytic hierarchy process known as FAHP processes the pair-wise pairing numbers into fuzzy triangle numbers to lower the priority of different selection criteria and attributes. A fuzzy AHP model has been developed to select the most appropriate supplier based on selection criteria and capacity and split orders among these suppliers so that the company can maximize the producer's profit.

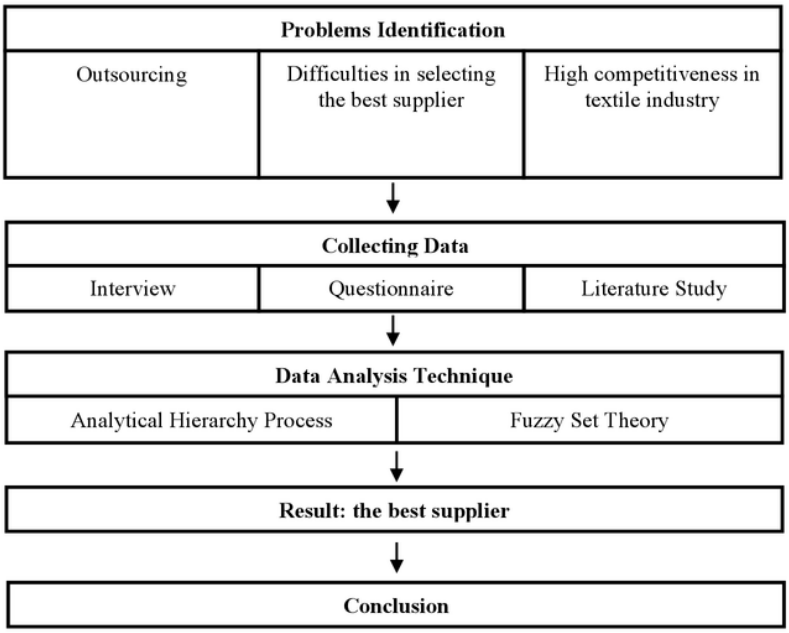

Figure 1. Framework
Source: Author (2018).

MATERIALS AND METHODS

This study is quantitative with a company as unit analysis and cross-section time horizon. The data used in this study is both primary and secondary data and the data collection method are questionnaire, interview with the top management of the company, and literature review, where author collect data about the backgrounds and methods for this research from books, journals, and internet.

Analytical Hierarchy Process (AHP), proposed by Thomas L. Saaty in Know (2008), is a quantitative alternative method of choice that relates to one or more of the criteria under consideration (Boroushaki & Malczewski, 2008; Lin F. et al, 2007). There are six steps in this process (Vahidnia, Alesheikh, Alimohammadi & Bassiri, 2008):

1) Describing the unstructured problem,
2) Detailed criteria and alternatives,
3) Recruiting pair wise comparisons among decision elements,
4) Using the eigen value method to predict the relative weights of the decision elements.

More specifically, the process consists of the following steps:

1. Decomposing the decision problem into a hierarchy (Srichetta and Thurachon, 2012). Arrange the decision problem into a structured hierarchy starting from the destination to the lowest level containing the alternatives to which you wish to choose. The upper level of the hierarchy is the overall goal to be achieved from the decision problem; the intermediate level is the criterion and sub-criteria that will influence the decision; and lastly the lower level which are possible alternatives.

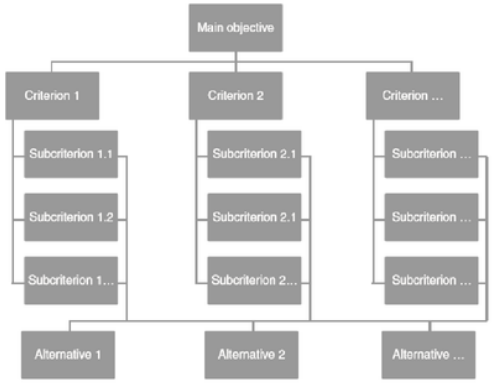

Figure 2. The Hierarchy Process
Source: Secundo, Magarielli, Esposito & Passiante (2017).

2. Calculating the relative importance weights of decision criteria in each level of the hierarchy using pair-wise comparisons (Srichetta and Thurachon, 2012). Use a fundamental scale or a 1 (to 9) weighting system proposed by Saaty (2008) to make pairwise comparisons so that the results can be summarized in the evaluation matrix. This process simultaneously determines the relative influence of decision elements at each hierarchy level.
3. Estimation and consistency measurement of local priorities (Secundo, Magarielli, Esposito & Passiante, 2017). The "local priorities" are the weights and judgments given to the criteria that indicate preferences among alternatives. Local priority values are known by normalizing the main eigenvectors α corresponding to the largest eigenvalues of pairwise comparison matrices. Then, a consistency ratio calculation is performed to determine the quality of a local priority vector that relies heavily on λmax and the order n matrix, with a value not exceeding 0.1.
4. Synthesis of local priorities into global priorities (Secundo, Magarielli, Esposito & Passiante, 2017).

According to Srichetta and Thurachon (2012), the step of aggregating the pair-wise comparison and the synthesis of the priorities to determine the overall priorities of the decision alternatives will be done.

1. Triangular fuzzy numbers
2. Construct the fuzzy pair-wise comparisons matrix
3. Aggregate the group decisions
4. Compute the value of fuzzy synthetic extent
5. Approximate the fuzzy priorities
   Consistency test of the comparison matrix.

The whole process of Fuzzy AHP is shown as the following flowchart:

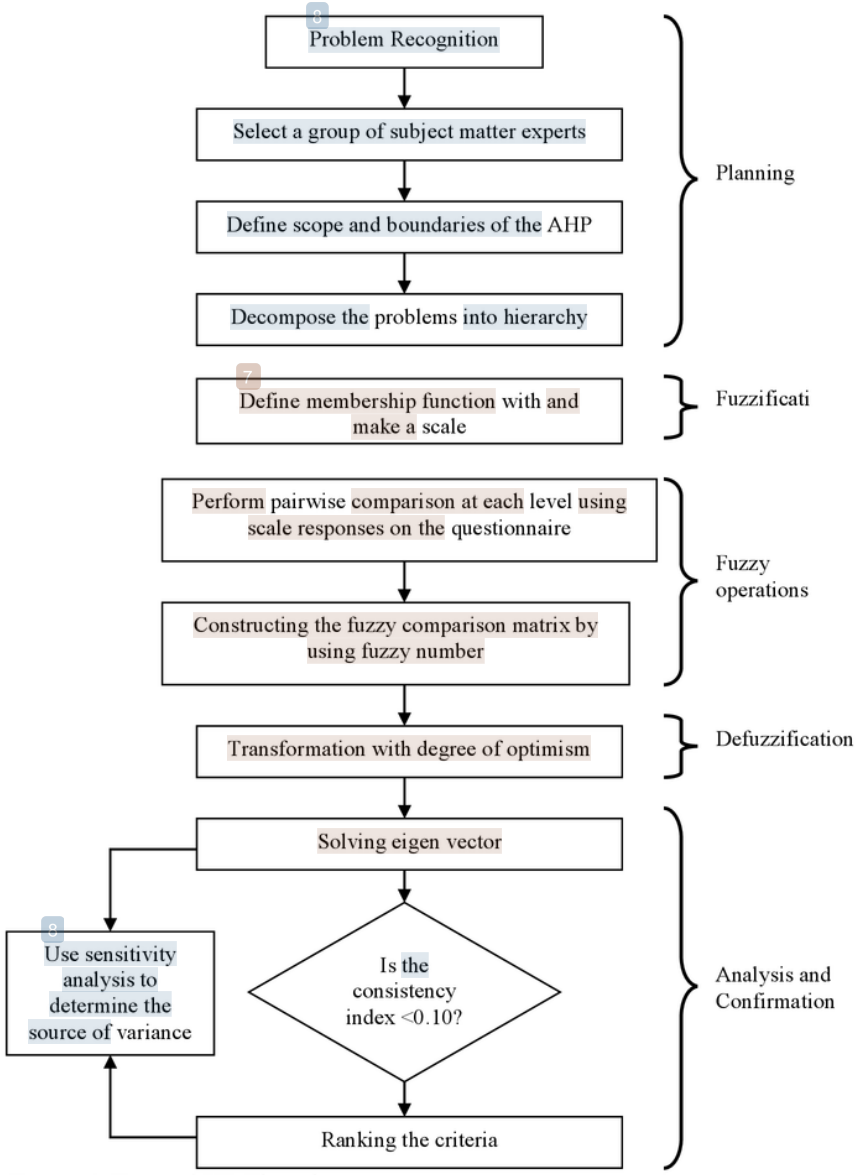

Figure 3. Fuzzy AHP Flowchart
Source: Jain, Singh and Mishra (2013).

RESULTS AND DISCUSSIONS

The arrangement of the criteria used in this study is based on the journal of Khan, Jayant, Kumar (2015). After finding the decision problem, the next step is to compose it into a structured hierarchy starting from the destination to the lowest level containing the alternatives to which you wish to choose. The upper level of the hierarchy is the overall goal to be achieved from the decision problem; the intermediate level is the criterion and sub-criteria that will influence the decision; and lastly the lower level which are possible alternatives. The alternatives will be divided into 3 types; yarn, knitting and dyeing suppliers.

Data collection is done by distributing 5 questionnaires to some experts in the trading company in TPT industry who has a direct

relationship with alternative suppliers to support the validity of data.

Pairwise comparison is conducted to calculate the relative importance weights of decision criteria and sub-criteria in each level of the hierarchy. A fundamental scale by Saaty (2008) is used for weighting system to make pairwise comparisons.

After author process the collected data with Pairwise comparison and TFN (Triangular Fuzzy Numbers), author calculate the result and find out the weight of each criteria and rank them as shown in the following table:

Table 2. *Fuzzy AHP Weights of Criteria*

Criteria	Weights	Rank
Cost	0.0641	4
Quality	0.5021	1
Delivery	0.1641	3
Service	0.2698	2

Source: Data Primary Processing (2017).

Then, authors calculate the processed result to find out about the weight of each sub-criteria and rank them as shown in the following table:

Table 3. *All Sub-criteria in Priority Order*

Rank		Sub-criteria	Final Weights
1	Q4	Inspection methods	0.2454
2	Q3	Order completeness	0.1503
3	S1	Responsiveness	0.1420
4	D4	Compliance with delivery dates	0.0666
5	Q1	Quality management	0.0562
6	S2	Modification capability	0.0560
7	D1	Delivery lead time	0.0517
8	Q2	Low rejection rate	0.0502
9	D3	Arrive in good condition	0.0477
10	S3	Reliability	0.0472
11	C4	Payment system	0.0265
12	C3	Quantity discount	0.0256
13	S4	Complaint resolution	0.0245
14	C2	Transportation cost	0.0128
15	C1	Meet price standard	-0.0009
16	D2	Right location delivery	-0.0019

Source: Primary Data Processing (2017).

Based from the results, it can be seen that Quality is the most important criteria in determining the best supplier. Moreover, its sub-criteria, Inspection Method, is the most important sub-criteria among the others.

Producing the best product quality need a good production system that requires further examination and quality control in order to confirm the results the determined standard. Therefore, a good inspection method is required as it enables the company to fix the sources of defects immediately after they are defected, and it is useful to improve productivity, reduce defect rates and reduce re-work and waste.

The results of this study show that the quality has the highest weight among other high-level decision criteria, followed by service, delivery and cost. It means that quality is the most important criteria for the company in selecting the best supplier. Similar studies conducted by Khan, Jayant & Kumar (2015) and Ozfirat, Tasoglu, Memis (2014) also show that quality criteria has the highest weight results and is the most important criteria in the selection of the best suppliers in a manufacturing company. However, the results of this study are not in line with the study conducted by Secundo, Magarielli, Esposito and Passiante (2017) which shows that the functional suitability and supplier characteristics (reputation) are the criteria with the highest weights and are the most important weights in choosing the best supplier.

CONCLUSIONS

By using Fuzzy AHP approach, author find out the most important criteria and sub-criteria for the company based on the calculated and processed weight of importance. The result of Fuzzy AHP calculation shows that quality is the most important and most influential criteria in the supplier selection process. The calculation also shows that inspection method is the most important and most influential sub-criteria in the supplier selection process.

From the result of this research, company is expected to be able to make an accurate decision considering these criteria and sub-criteria. Author also suggest the company to develop the criteria and sub-criteria used in supplier selection process using Fuzzy AHP approach depending on the situation. Company is also suggested to apply Fuzzy AHP approach for other practical decisions within the company such as in selecting the candidates who are eligible to be promoted.

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